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SID 62-300-2

APOLLO MONTHLY PROGRESS REPORT (U)

28 February 1962

CLASSIFICATION CHANGE
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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

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FOREWORD

On 28 November 1961, Space and Information Systems Division of North American Aviation was informed that it had been selected as the principal contractor for the Project Apollo Spacecraft.

Apollo Letter Contract NAS 9-150 was executed on 21 December 1961. For program planning purposes, a go-ahead date of 1 January 1962 was established.

Based upon the Project Apollo Spacecraft Development Statement of Work, 26 separate areas of effort have been defined. This report reflects the progress made in these areas during the second month of program activities.

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ILLUSTRATIONS

TABLES

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FLIGHT TECHNOLOGY

AERO-THERMAL WIND TUNNEL TEST PROGRAM

NASA wind-tunnel test data on the adaptation of the Little Joe-I booster to the Apollo launch escape system (LES) have been analyzed. Results show the configuration to be statically unstable at zero angle of attack. At subsonic Mach numbers, the aerodynamic center was located 5 body-diameters ahead of the center of gravity. Tests with the stabilizing fins removed from the configuration revealed no change of position in the aerodynamic center. As the fins were completely immersed in a separated wake that originated near the command-module maximum diameter, results indicate that the fins made no contribution to the static stability of the configuration. Since the Little Joe-I concept is for a fin-stabilized system, aerodynamic effort to adapt this booster to the Apollo LES is terminated.

Table 1 summarizes the status of current model and test activities.

The first dynamic stability model has been shipped to Langley Field on schedule.

THERMAL ANALYSIS

A preliminary analysis of the thermodynamic requirements of the fuel cell was completed. The preliminary analysis of typical heat dissipation systems was continued in order to provide a tool for rapid determination of the optimum configuration of fuel-cell system components. Upon determination of the fuel-cell source, a detailed analysis will be initiated.

Application of the IBM-7090 computer program, currently being employed for space-radiator sizing, will be necessary to ensure that the design parameters of the selected fuel-cell system can be accommodated.

A preliminary analysis has been performed to size the radiator for the fuel cell. This work will establish test requirements for performance evaluation of such components.

A system was established for disseminating design values for heat-dissipation hardware parameters and maintaining distribution of current data.

Table 1. Test Status, February 1962

Test Objective	Model Designation	Facility	Test Schedule	Status as of 28 Feb 1962	Planned Status as of 31 Mar 1962
Static Stability					
Preliminary aerodynamic force data using simple, readily constructed models with detachable escape towers, Mach 1.5 to 9.5. First hypersonic data to be obtained in these tests.	FS-1 (0.02 scale)	NAA SAL JPL 21 in. JPL 20 in.	19 Feb 2 Feb 5 to 9 Mar 2 to 6 Apr	Test in NAA SAL wind tunnel in progress. Pretest report for JPL tests issued.	SAL test completed and data report published. JPL 21 in. test completed.
Basic evaluation of design. Command module (CM) with detachable escape tower configurations. Mach 0.7 to 2.6; provides more complete simulation of CM and LES (power-off).	FS-2 (0.105 scale)	Ames 9 by 7 ft Ames 11 ft Ames 8 by 7 ft NAA TWT NAA NAAL	19 to 23 Mar 26 to 30 Mar 7 to 11 May 9 to 20 Apr 21 to 25 May	Design complete; construction 95% complete; will ship model 5 Mar for Ames Tests. Test dates firm: pretest report issued for Ames Tests.	Construct stings for TWT and NAAL tests. Ames 9 by 7 ft and 11 ft tests completed. TWT pretest report issued.
Aerodynamic force data at hypervelocities for the re-entry and hypersonic abort configurations.	FS-4 (0.04 and 0.026 scale)	AEDC HS 2	18 to 29 Jun	Design 70% complete. Preliminary planning conference held at AEDC. Tests dates firm.	Design completed. Model construction approximately 50% complete.
Parametric study to investigate effect of command module corner radius, heat shield radius, and afterbody angle.	FS-7	JPL 21 in. JPL 20 in.	12 to 16 Mar 9 to 13 Apr	Design complete. Construction 15% complete. JPL 21 in. test date firm.	JPL 21 in. test completed. JPL 20 in. or NAA SAL test confirmed with pretest report issued.
Dynamic Stability					
Dynamic stability of command module and launch escape system. Covers transonic; Mach 2.3 to 5.0.	FD-1 (0.02 scale)	JPL 20 in.	7 to 11 May	Preliminary planning conference at JPL.	Design initiated, test plans firm.
	FD-2 (0.055 scale)	Langley 4 by 4 UPWT Langley 8 ft Transonic Pressure	5 to 9 Mar 19 to 23 Mar	Design and construction complete. Model shipped (17 Feb 62).	Both Langley tests completed.
Pressure Distributions					
Pressure distributions on CM and escape rocket for early loads data.	PS-1 (0.02 scale)	JPL 20 in. JPL 21 in.	12 to 13 Mar 2 to 13 Apr	Design and construction complete. Pretest report issued.	JPL 20 in. test completed.
Pressure distributions at hypervelocities on the re-entry and hypersonic abort configurations.	PS-4 (0.04 and 0.026 scale)	AEDC HS 2	2 to 27 July	Preliminary design studies started. Test dates firm.	No further effort before April 1962.
	PS-5	CAL 48 in. Shock	4 to 15 Jun	Preliminary test conferences held at CAL.	Design initiated.
Steady State and transient pressure measurements on launch configuration.	PSTL-1	NAA TWT NAA NAAL	23 to 27 Apr 4 to 8 Jun	Studies to establish design concept, model scale, and instrumentation requirements have begun.	Design 50% complete, construction initiated. Establish type of instrumentation. Issue pretest report.
Heat Transfer					
Heat transfer rates for re-entry configuration, launch escape system, and hypersonic abort.	H-1	JPL 21 in.	16 to 27 Apr	Instrumentation and design concept established. Detail design 60% complete. Test dates firm.	Complete design and construction planned to ship to JPL 5 Apr 62. Pretest report issued.
Structural Dynamics					
Investigate problems associated with buffeting on SA-5 at transonic speeds during launch.	BD-1 (0.08 scale)	Langley 16 ft Transonic Dynamic	9 to 20 July	Held preliminary planning conference at MSC, Houston, 20 Feb 62. Started preliminary design studies.	Complete preliminary design studies and attend design conference at LRC 7 Mar 62.

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HEAT SHIELD

The current computer program for determining the thickness requirements of the ablative materials has been deemed inadequate to handle the degree of sophisticated analysis required for the many kinds of char-forming ablative materials being considered for the command module. Therefore, a new and more refined program is being initiated for future analysis.

PERFORMANCE AND TRAJECTORIES

Design trajectories have been established for the loads and heating analysis. The trajectories are limited to atmospheric flight and represent extreme combinations of loads and load duration.

Determination of the orbital-payload capability of the Saturn C-1 booster has been made; the latest available drag, weight, and operational characteristics (presented in the Saturn Design Criteria Manual published by NASA) were used in making this determination. Table 2 presents the performance capability obtained for both 7 and 8-engine, S-I stage boost trajectories. The payloads include the second command module, service module, and adapter. The 3,000-pound booster guidance system is included as S-IV burnout weight, not as payload.

Table 2. C-1 Orbital Payload Capability

Altitude (nautical miles)	7-Engine S-I Payload (lb)	8-Engine Payload (lb)
100	19,744	22,269
150	18,264	20,809
200	16,482	18,966
250	14,460	16,951
300	-	14,478

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There are four basic differences in the data used by S&ID and NASA for computing payload and entry velocity values:

1. Using the current, NASA-furnished C-1 drag curve, S&ID obtains drag values 50 percent greater than those tabulated in the NASA trajectories. Therefore, NASA-tabulated trajectory data appear to be based on the block-1 Saturn configuration, i.e., with no fins. However, the overall result of this inconsistency is small.

2. For trajectory computation, S&ID uses a 3-second hold-down at S-I mainstage operation; this uses 2.1 percent of the first-stage available propellants. The NASA trajectories apparently do not include this effect. It has been determined that this operational characteristic results in a loss of about 144 fps, for super-orbital entry tests, or 431 pounds of injected payload into orbit (200 n mi).

3. To compensate for launch azimuth deviations, unfavorable wind profiles, guidance and control deviations, propulsion tolerances, etc., S&ID reduces the second-stage, nominal, specific impulse by 2 percent and the available propellant by 0.5 percent. The NASA data, in contrast, uses the nominal, specific impulse with 0.5 percent propellant reserve in an orbit mission, and with no reserve in the super-orbital test mission. This difference in assumption produces a velocity decrement of 540 fps for super-orbital entry tests or an injected, payload-weight difference (at 200 n mi) of about 1600 pounds.

4. The NASA, typical, super-orbital test-entry trajectory allows about a 40-second time interval between S-IV stage burnout and the start (10 psf) of high q build-up during entry. The S&ID trajectories were computed with an assumed time interval of 160 seconds because it was not known what interval was necessary to effect adequate separation as well as the required attitude reorientation of the command module through about 180 degrees. This assumption also results in a significant velocity penalty, because burnout of the booster must occur at a higher altitude. The required time interval is under investigation.

AERO-THERMODYNAMICS

Re-entry aerodynamic heating-rate estimates have been computed in support of the Apollo command-module size-and-shape study. These values are more refined than those previously quoted because of two innovations

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incorporated into the IBM program: (1) Loes' laminar heat transfer distribution on the blunt face and (2) use of a range of wall-temperature values for computing heat-transfer rates at any body location.

Work has proceeded on defining the requirements of the Apollo aerodynamic-heating, wind-tunnel test program. Requirement specifications for the first test (H-1 models at the Jet Propulsion Lab facility) are nearly complete (Table 1).

AERODYNAMICS

Aerodynamic characteristics for low Mach number (0.3 to 1.2) of the command module have been published. This compilation is based on NASA wind-tunnel test data and will provide the necessary characteristics for preliminary design requirements of the flight control and parachute recovery systems.

Entry aerodynamic characteristics of the command module have been studied for a series of heat-shield radii, corner radii, and afterbody angles. The results provide a useful library of data for trajectory studies of erosion effects and center-of-gravity requirements during entry.

In support of analytical estimates, an experimental parametric study of the command module geometry has been initiated.

PROPULSION SYSTEM ANALYSIS, THERMODYNAMICS

Thrust vector control systems, including secondary injection and gimballing methods, are being evaluated.for the main service module and launch escape propulsion system. Propellant-line sizing for preliminary layout purposes has been accomplished for the main-propulsion and reaction-control systems of the service module and for the reaction control system of the command module.

A heat transfer analysis of the Marquardt reaction-control-system motor has been initiated. Thus far, chamber-wall and throat-wall temperatures have been estimated to be 3400 and 4100 degrees F. Work to determine the maximum temperature of the fuel after shutdown is being continued because a maximum value of 250 F can be tolerated.

Analytical methods of evaluating rocket motor exhaust plume characteristics have been determined. The first part of a study on helium-storage-vessel sizing for the service-module design was completed.

ANALOG-DIGITAL SIMULATION

A real-time, analog-digital, six-degree-of-freedom, re-entry simulation is currently in operation. Computing facilities utilized are a Packard Bell TRICE DDA, 240 amplifiers, a cockpit (complete with controls and displays), and associated analog equipment.

An initial objective is to evaluate the effectiveness of the command-module, reaction-control system as a function of jet location, thrust level, and control-system logic based on vehicular, dynamic performance and propellant usage. A g-load and terminal-range, repetitive-prediction system is being mechanized and checked out for incorporation into the present mechanization.

The trajectory-shaping technique used with the prediction system requires the pilot to close the control loop between the control variables and the navigational display. With this control method, flying qualities at supercircular velocities will be investigated; range footprints will be determined; and terminal range sensitivities will be evaluated.

DIGITAL PROGRAMMING

A three-degree-of-freedom program for earth-boost and entry studies is being checked out. Coding has begun on additional options for the flight-programmer subroutines. These options are as follows:

1. Programmed lift, side-force, and drag coefficients
2. Programmed angle of attack and/or angle of sideslip
3. Programmed body-axes attitude angles and local Euler angles
4. Programmed wind-axes normal-load factor with thrust
5. Programmed flight-path angle versus altitude, with sideslip angle equaling zero

STUDIES

A study of flow versus pressure-drop for the environmental control system (ECS) space radiator is now in progress.

A study was initiated to establish the design requirements for the electronic equipment cold plates. An analysis is being made of several liquid-passage sizes, patterns, and flow rates, as related to heat transfer. In this study, the thermal analog computer will be used.

An investigation is being made to determine availability and capability of facilities for radiation-shielding testing. Independent test laboratories, universities, and government-owned facilities are being considered.

A list giving the physical and heat-load data of the R & D instrumentation to be supplied by NASA for SA-5 through SA-8 has been received. With this preliminary information, studies are being conducted to determine the equipment-cooling-system concept and requirements. At present, three configurations are being considered: (1) a pressurized command module, (2) a pressurized container within the nonpressurized module (to house the equipment) and (3) a group of small, pressurized containers within the nonpressurized module.

Water is now being considered for metabolic, sanitation, cooling, and radiation uses; additional emphasis will be placed on requirements analysis, on the basis of present efforts to achieve major vehicle weight savings.

Information relative to the lunar refrigeration system is being compared and integrated with the space radiator analysis work currently in progress.

A study is being conducted to determine the mechanism of solar-flare production and the manner in which the expelled particles are transported through space to the vicinity of earth. A literature survey is now being accomplished to obtain background information and recent advances in the state of the art.

PLANNED ACTIVITIES

During the next report period, detailed heat-dissipation requirements should become firm. A thorough study and analysis of the thermodynamic parameters will be initiated, and a more accurate prediction of necessary radiator size will be made. To determine operating parameters and to provide preliminary sizing, pertinent heat-dissipation hardware will receive analysis.

In March, aerodynamic tests will be conducted in the hypersonic wind tunnel of Jet Propulsion Laboratory.

A study of new gas storage requirements will be conducted on the basis of separate containers for gases and possible changes in tank requirements. A pressure-drop analysis for the cold plates of the electrical equipment will be initiated for various heat-transfer configurations.

Laboratory tests of several test cold-plates are being planned for an early analysis and for an experimental investigation of the problems involved

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with contact resistance, heat-load distribution, and interaction of black boxes. It is anticipated that initial test-program requirements and procedures will be established and then transmitted to the laboratory during the latter portion of next month.

The preliminary work statement for noxious-gas identification and removal will be completed.

Future work to be conducted on the ablative heat shield is as follows:

1. Continuation of radiator analysis and design
2. Establishment and initiation of test plan for evaluating ablative materials
3. Completion of computer program for analysis of ablative materials
4. Determination of test capabilities of supplier facilities
5. Determination of effect of lunar heat load on fixed versus movable radiators
6. Determination of heat loads for lunar orbit
7. Determination of heat loads for earth orbit
8. Determination of heat loads for translunar flights
9. Determination of surface-finish requirements
10. Determination of structural thermal distribution
11. Study of insulation requirements
12. Determination of vehicle-orientation requirements

The following problem areas in the propulsion system are being studied:

1. Further information from Aerodynamics and Motor Design regarding aerodynamic stability and motor case L/D will be required before final evaluation of tower jettison systems can be completed.

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2. A decision on the eligibility for consideration of thrust vector control by secondary injection, for Apollo application, will be required to justify continuation of a study program.

PROBLEM AREAS

The following problem areas exist:

1. Overall lunar heat rejection

    a. Radiator configuration and rejection capacity

    b. Lunar environmental heat loads

    c. Radiator-area availability on service module

2. Internal and external temperature-time histories for service and command module, for all mission modes, to establish environmental operation conditions

3. Expected trace contaminants, to further design of catalytic-burner and gas-analyzer requirements

INTEGRATION AND SYSTEM ANALYSIS

SYSTEM SPECIFICATIONS

Performance and interface specifications for the command, service, and lunar-landing modules and the adapter have been prepared and will be released on schedule.

Spacecraft-performance and design-criteria specifications have been prepared and will be released on schedule.

The electromagnetic-interference (EM-I) control plan has been prepared.

An overall grounding-criteria document for the Apollo propulsion system, launch complex, support building, and associated equipment is being prepared.

The requirement specifications have been completed for boilerplates 1 through 8.

SYSTEM ANALYSIS

The service-module configuration selected for interim design efforts was defined during this reporting period.

For review of checkout procedures and evaluation of proposed methods of checking spacecraft systems, a committee on checkout criteria was formed.

Efforts to establish abort criteria were begun; these criteria will define parameters contributing to an abort condition, the procedures for monitoring these parameters, and the methods for initiating an abort action. Work will continue in this area.

SPARES

Action has been taken to establish the spares review team, which will consist of Engineering, Quality Assurance, Logistics, and Manufacturing personnel. The initial meeting of the spares review team is scheduled for 8 March 1962. At this time spares will be selected for boilerplates 1 and 4 and their associated ground support equipment.

CONFIGURATION CONTROL

The principal contractor-associate-contractor interface control methods have been formulated and coordinated with MIT and NASA.

STABILITY AND CONTROL DATA

The preliminary data requested by Minneapolis-Honeywell (M-H) has been provided. It included six degree-of-freedom, motion equations, written in a form suitable for describing the dynamics of tumbling flight, the aero-elastic data required for preliminary studies, and the Saturn C-1 and C-5 trajectories computed by S&ID.

Preparation of the official launch escape system stability-and-control data manual has begun.

PLANNED ACTIVITIES

Configuration and change-control procedures are planned; they will relate to all subcontractors. Studies to update the service module configuration are also planned. A preliminary spacecraft checkout plan will be prepared during the next report period.

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RELIABILITY

DESIGN ANALYSIS

A preliminary reliability and crew safety apportionment has been completed for each spacecraft system. Requirements are defined for the 14 most significant lunar-landing and earth-return mission phases.

An environmental-criteria handbook is also being prepared to relate environmental stresses (including time) to each mission phase.

At a briefing in Houston, Texas, the results of a reliability study of the mission propulsion systems were presented to NASA at the Manned Spaceflight Center (MSC). Although a single-engine service-module configuration was selected over the four-engine installation, reliability studies are continuing to better define quantitative comparisons between the two configurations.

In support of a study to determine the most desirable system for Apollo applications, a reliability analysis of four earth-landing attenuation subsystems has been completed. The configurations evaluated include impact bags, retro-rockets, frangible honeycomb, and shock struts.

DESIGN AND PERFORMANCE CRITERIA SPECIFICATIONS

Initial spacecraft- and GSE-design reliability requirements have been prepared in support of the design and performance criteria specifications.

PLANNED ACTIVITIES

Reliability and crew-safety analyses of all systems will continue during the next reporting period.

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INSTRUMENTATION

CONTROLS AND DISPLAYS

While the preliminary design criteria were being generated, parallel efforts were directed toward determining the control and display parameters and their performance specifications. Updating this information will continue as each system becomes better defined. Current studies have revealed problem areas in weight, volume, and power requirements. In approaching these problem areas, analyses will be made; and trade-offs will occur in the types of displays best suited to portray the readout functions.

An instrument simulator, displaying the entry corridor bordered by skipout and over-stress, has been constructed as a possible back-up display for the crew in the event that manual entry must be accomplished. This model demonstrates the display principle.

SYSTEM INTERFACES

A standard modular packaging concept, compatible with or adaptable to requirements of the major electronic subsystems, was developed. The concept affords a high degree of location flexibility, weight-space thermal management, and circuit accessibility; it also affords uniform control of tolerance, cable connector, configuration, identification, and mounting and permits an early freeze of the command-module structure.

BOILERPLATE EARTH-DROP TEST

The procurement specifications required for instrumentation and equipment in support of the boilerplate earth-drop test have been completed.

PLANNED ACTIVITIES

The following equipment will be available for the No. 1 semihard mockup:

1. Display and controls to demonstrate the coplanar portion of the rendezvous maneuver

2. A simulated crew readout, delineating the output reading of the in-flight training system (IFTS)

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The packaging concept will be compared with alternative approaches and a specific design, coordinated with other Apollo areas, will be prepared for formal design review.

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SIMULATION AND TRAINING

MOCKUPS

The semihard mockup was completed last month, ahead of schedule.

TRAINING SYSTEM ENGINEERING

The initial and final release dates of the engineering drawings for training equipment were established. Trainer perspective drawings have been completed for the moon-base-operation trainer, weightless-procedure tank trainer, launch-escape-system trainer, communications-system trainer, and service-module reaction-control-system trainer.

Trainer maintenance descriptions have been revised because of system modifications; they were finalized for inclusion in the Training Equipment Requirements Specification.

PLANNED ACTIVITIES

The preliminary test equipment lists have been completed for system investigation; however, as the requirements for the mission simulator become firm, it is anticipated that modifications and additions will be required to support the development testing of this complex simulator.

Other activities that have been programmed for the next reporting period are the following:

1. Finalization of the training equipment requirements specification

2. Completion of trainer perspective drawings

Two cabin-interior mockups are in work and on schedule, and effort will begin on cabin exterior equipment and adapter-interface mockups.

During March effort will be directed to continuing delineation of the training program's content and scope. It is anticipated that a working discussion with NASA will be arranged for mid-March. This discussion will center on elaboration and refinement of training requirements and activities within the Training Plan (SID 62-162). Also during March, continued effort will be expended on the development of training-information format and flow channels and the analysis of engineering data for training implications. In acticipation of training equipment performance specifications, support to training equipment design will receive special emphasis.

SPACECRAFT TEST OPERATIONS - DOWNEY

Detailed test plans are being prepared for the major ground test areas, with respect to facilities, special test equipment, and GSE.

The AMR test site has been reviewed by NASA for possible use as a location for the propulsion development test stand. NASA has notified S&ID that AMR, AF and PAA personnel are not receptive to a test facility of this type at AMR. Therefore, the S&ID-selected facilities at McGregor, Texas, will again be proposed to NASA for the location of the test stand.

Preliminary instrumentation measurement lists have been prepared. These measurement lists have been directed toward specific launch and ground test vehicles and are also being used to derive a master measurement list for the Apollo program.

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DOCUMENTATION

The following S&ID documents were published during this report period:

1. Program Control Plan (SID 62-223)
2. Manufacturing Plan (SID 62-102)
3. Qualification Reliability Test Plan (SID 62-204)
4. Support Plan (SID 62-96)
5. Training Plan (SID 62-162)
6. Mockup Inspection Plan (SID 62-200)
7. Quality Control Plan (SID 62-154)
8. Facilities Submittal Plan (SID 62-153)
9. Monthly Progress Report (SID 62-300-1)
10. Initial Weight and Balance Report (SID 62-99)
11. Wind Tunnel Test Reports (SID 62-100, 170, 246, and 252)
12. Spacecraft Performance Specifications (SID 62-51)
13. Spacecraft Module and Adapter Specifications (SID 62-52, 53, 54, and 55)
14. Ground Support General Equipment Specification (SID 62-50)
15. GSE Performance and Interface Specification (SID 62-57)
16. Apollo Design Criteria Specification (SID 62-65)
17. Mockup Specifications
18. Boilerplate Specifications
19. GOSS Performance and Interface Specification (SID 62-76)
20. Hardware List (SID 62-58)
21. Preliminary Apollo Interface Coordination and Control Methods Document (SID 62-271)
22. Preliminary Apollo Associate Contractor Operating Procedure (SID 62-270)

A joint review of the Reliability Program Plan (SID 62-203) was accomplished by NASA and S&ID reliability personnel. The document is being revised to include additional detail and significant items requested by NASA personnel.

A model reliability program plan is being prepared for subcontractors and suppliers to ensure uniformity in presentation of their plans to S&ID.

Models of the Qualification Reliability Test Plan are also being written for transmittal to S&ID subcontractors and suppliers.

A meeting was conducted with NASA at S&ID to review their comments on the Apollo Test Plan (SID 62-109). The required additions and revisions are in work, and the requested first revision will appear during the next report period.

The revised Apollo Facilities Plan (SID 62-153) is being prepared for submittal to NASA.

Revision to the Apollo Support Plan (SID 62-96) will be initiated after coordination of the preliminary edition with NASA.

Spares, GFE, and GFAE will be added to the hardware list by revision immediately upon identification.

Formulation and preparation of the Apollo maintenance plan, the spacecraft familiarization manual, and the flight operation manual are progressing as scheduled.

A facilities submittal schedule has been prepared and submitted to the local NASA representative. It outlines the planned submittal dates for the Appendix A documents required to obtain facilities contract funds for the construction of the major new facilities that will support the Apollo development program. The documents involved are as follows:

1. Advance Facilities Appendix A data

2. Preliminary Facilities Appendix A for the Propulsion Systems Development Facility

3. Preliminary Facilities Appendix A for Air Force Plant No. 16 Facilities

4. Revised Facility Plan

5. Addendum to Facilities Appendix A Air Force Plan No. 16, to cover items other than the major building requirements.

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PROGRAM MANAGEMENT

The first Apollo status briefing was presented to NASA on 19 February at Houston, Texas. (Refer to Table 5, page 64, for February 1962 meetings.)

OPERATING PROCEDURES

Operating procedures for the S&ID associate contractor relationships and the interface coordination and control have been discussed with MIT and NASA.

S&ID representatives attended Apollo navigation and guidance conferences at Houston and identified many inconsistencies between S&ID schedule requirements and MIT-planned delivery schedules. Also, the respective responsibilities of S&ID and MIT for navigation- and guidance-equipment installation and checkout were discussed.

SUBCONTRACT EFFORT

Subcontractors are now operating under letter contracts for the earth-landing system, the environmental control system, the telecommunications system, and the stabilization and control system.

Negotiations are being carried on for the launch escape motors. Marquardt has been selected for the reaction control system.

The Lockheed Propulsion Company, a division of Lockheed Aircraft, was selected as supplier for the launch escape motor.

AiResearch has received a letter contract from S&ID for design, development, and test of a major portion of the environmental control subsystem (ECS) components.

A letter contract from S&ID for the Apollo telecommunication system was given to Collins Radio.

S&ID selected RCA as subcontractor for a ground operational support system (GOSS) study program.

The specification for the R & D antennas (including those required for the Little Joe-II vehicles) will be completed and released for bids about the middle of March.

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A preliminary work statement and a proposal request for the service-module propulsion engine were presented to prospective suppliers. Liquid rocket engine manufacturers invited to submit proposals included Aerojet-General, Astropower, Bell, United Aircraft, Rocketdyne, and Thiokol-RMD. Replies to the proposal request are due on 12 March 1962.

A briefing held on 7 February 1962 presented a request for proposal for the escape-tower jettison motor to prospective suppliers. Proposals were subsequently received on 21 February 1962 from Aerojet, Atlantic Research, Hercules Powder Co., Lockheed Propulsion Co., Rocket Power, and Thiokol Chemical Co. One-hour briefings were presented by representatives of each bidder on 22 and 23 February 1962. Review of the proposals is in progress, and announcement of the winning bid is tentatively scheduled for 12 March.

Proposals on the fuel-cell system have been received from Pratt & Whitney, Allis-Chalmers, TAPCO, and General Electric and evaluated. Pratt & Whitney was selected.

Proposals by prospective subcontractors are being evaluated for the head shield, the fuel cells, and the escape-tower jettison motor.

Proposals submitted to Minneapolis-Honeywell (by Rocketdyne, Marquardt, TAPCO, Aerojet and Bell Aerosystems) were evaluated to verify their selection of the Marquardt Corporation as supplier of the reaction control engines for the command and service modules.

On 22 February, the Marquardt Corporation was awarded the contract for design, fabrication, and testing of the reaction control engine assemblies.

Under the present plan of action, the selection of the thrust-vector control system to be employed on the delivered motor will be made approximately six weeks after completion of contract negotiations with the Lockheed Propulsion Company (LPC). LPC will contract the Lockheed Missiles and Space Division and Arde-Portland to conduct design and analysis studies of fluid-injection and hinged-nozzle systems for thrust-vector control. These companies had previously been active in their approaches to thrust-vector control on the Polaris and Minuteman missile programs.

Personnel of S&ID visited the Lockheed Missiles and Space Division, as shown in Table 5, to review the various thrust-vector control systems employed on the Polaris missile. During this visit, particular attention was given to fluid injection systems with respect to their application to the Apollo launch escape system. A similar discussion of the hinged-nozzle system was held at S&ID, on 27 February, with personnel of the Arde-Portland Company.

PERT

The second scheduled S&ID/NASA PERT coordination meeting was held at S&ID on 21 and 22 February. Considerable discussion developed around the integrated network concept and the implementation of a mutually satisfactory network and event numbering system. NASA personnel stated that the latter item would be resolved at the 6 March, PERT Coordination Meeting at MSC.

Network preparations are proceeding normally and it is expected that all March PERT schedule committments will be met.

A more definitive set of schedule milestones for flight technology was completed.

In conjunction with the accelerated implementation plan for the Apollo/PERT program, subcontractor personnel were given a technical training course on NASA/S&ID PERT during the week of 15 February. Subcontractor personnel in the course were from Minneapolis-Honeywell, Radioplane, AiResearch, and Collins Radio.

[redacted]

STABILIZATION AND CONTROL

SYSTEM ANALYSIS

Facilities and equipment requirements for the stabilization and control system and the component laboratory have been prepared. A stabilization and control test plan that includes both S&ID and Minneapolis-Honeywell planned development testing has also been prepared.

Pulse-modulation electronics were breadboarded for both preprogrammed pulse width and pulse-width versus repetition-rate techniques. These have been tied into the analog computer to determine comparative system performance for a variety of assumed initial conditions. The resulting data are now being analyzed.

A set of simplified equations of motion was derived; control moments were established; and a control system for re-entry was synthesized.

A laboratory fluid investigation pointed out a problem area in the rocket-engine gimballing details. Several gimballing methods are available, but support systems will depend on the selected method of gimballing. Once this method has been established, test equipment and instrumentation will be selected; and a close liaison with the responsible design groups will be maintained.

SYSTEM SUPPORT

In a meeting held on 13 February 1962, Minneapolis-Honeywell (M-H) engineering personnel presented a draft format of their environmental R & D program for electronic materials. This program was proposed in support of M-H engineering and technical proposals to Statement of Work for the Stabilization Control System Subcontractor (SID 62-11).

The launch escape study programs were also reviewed with the M-H engineers. A joint trip was made to Lockheed, supplier of the launch escape motor, to determine the dynamic and reliability aspects of the post-nozzle injection method of achieving thrust vector control.

PLANNED ACTIVITIES

To determine the effects on angle of attack, vehicle stability, flight path angle, and changes in mass and inertia, investigations will continue to be made at critical points in the launch escape subsystem dynamics on various abort trajectories.

Quantitative trade-offs between the single and four-engine service engine control systems will be made concurrently with the design analyses of the present single-engine service engine.

Other activities that have been programmed for the next reporting period are as follows:

1. Initiation of a chemical study of electronic materials of potential toxicity

2. Investigation into the performance of proposed pulse modulation schemes in the presence of typical mid-course disturbances

3. Establishment of vehicle-orientation requirements for all phases and the resulting sensor requirements

CREW PROVISIONS

WASTE MANAGEMENT

Work on a comprehensive waste system schematic is in progress. Reduction of weight, conservation of power, and positive separation of the food vent system from the waste vent system are being studied.

WATER SUPPLY

The water supply and usage requirements are being re-examined for a number of mission configurations and requirements. Results of these studies will determine the total quantities required and the design and location of tanks within the command and service modules.

COUCH DESIGN

During the past month, the couch-design layout has progressed to a configuration stable enough to enable other groups, whose work relies on the couch design, to proceed with their own requirements and designs.

PLANNED ACTIVITIES

Define and initiate support programs.

LAUNCH ESCAPE SUBSYSTEM

TESTS

Tests on the stability characteristics of the launch escape subsystem have been started in the NAA SAL wind tunnel (Table 1). Preliminary investigations reveal that effects of the escape-motor exhaust can also be simulated in this tunnel and valid force and pressure data can be obtained from these tests.

AIR LOADS DATA

Preliminary analysis of the air-loads breakdown of the launch escape subsystem has been completed. The loads are based on data from NASA's precontract, wind-tunnel tests and will be revised upon completion of NAA tests. The air loads basic data manual has been started.

DROGUE CHUTE

A six-degree-of-freedom, dynamic analysis of the drogue chute portion of the earth-landing phase of flight has been initiated. Typical profiles of altitude versus velocity and flight-path angle are used as interface conditions between the entry and earth-landing phases. Angular and linear motions of the command module, prior to and during drogue-chute deployment and descent, are being evaluated to determine an acceptable domain of interface conditions and to define stability criteria.

ESCAPE-TOWER JETTISON MOTOR

A preliminary study has been made to determine the requirements for the escape-tower jettison motor. A more detailed computer simulation study is scheduled. Escape-tower jettison has been studied for three motor positions. Design curves have been prepared which present tradeoffs for the jettison-motor thrust, burning time, total impulse, and thrust-vector cant angle.

LAUNCH CONTROL SYSTEM STUDIES

Design studies were completed on eight different latching devices located at the four-leg base of the escape tower. These included several variations of single- and double-toggle latches, all to be held locked by a single mechanical system and to be released, simultaneously, from a central point in the tower, by a single explosive initiator. Also studied was a clamp ring, at the tower base, which was clamped to a circumferential fiberglass ring attached to the command module.

ESCAPE-TOWER DESIGN

A design study is in progress to attach the escape tower to the command module by means of a circumferential clamping ring (Marman Clamp). The portion of the command module structure that protrudes through the ablation material (and which will not be part of the clamping ring) will be made of a structural fiberglass product that has a low thermal conductivity characteristic. This will retard the inflow of heat to the inner structure during re-entry. If the design is possible, it will increase the tower stiffness and halp the natural frequency problem.

The escape-tower jettison motor has been established as a twin-nozzle motor located forward of the launch escape motor. A design study has been completed to widen the forward portion of the escape tower and to attach the escape motor by using the aerodynamic skirt as the structural attachment between the body of the motor and the tower.

Escape-tower design studies are now directed toward a configuration that locates the escape-tower jettison motor on the forward end of the launch escape motor, as illustrated in Figure 1. This change was introduced to reduce the amount of lead ballast carried at the forward end of the launch escape motor for control of the overall center-of-gravity position. Positioning of the escape-tower jettison motor at this location will also avoid its exposure to the exhaust plume of the launch escape motor.

LAUNCH ESCAPE MOTOR

Final requirements for the launch escape motor have been established. Maximum and minimum thrust levels were specified so that crew tolerances will not be exceeded and the capability to propel the command module a safe miss distance from the thrusting launch vehicle will be maintained. The thrust offset angle has tentatively been established at 2 degrees. The new thrust limits are illustrated by the curve in Figure 2. Launch escape motor dimensions, as modified by the increased performance requirements, are illustrated in Figure 3.

PLANNED ACTIVITIES

A study of candidate materials for the escape tower that are commensurate with the highest strength-to-weight ratios will be conducted. The development of fabrication techniques will be continued.

[redacted]

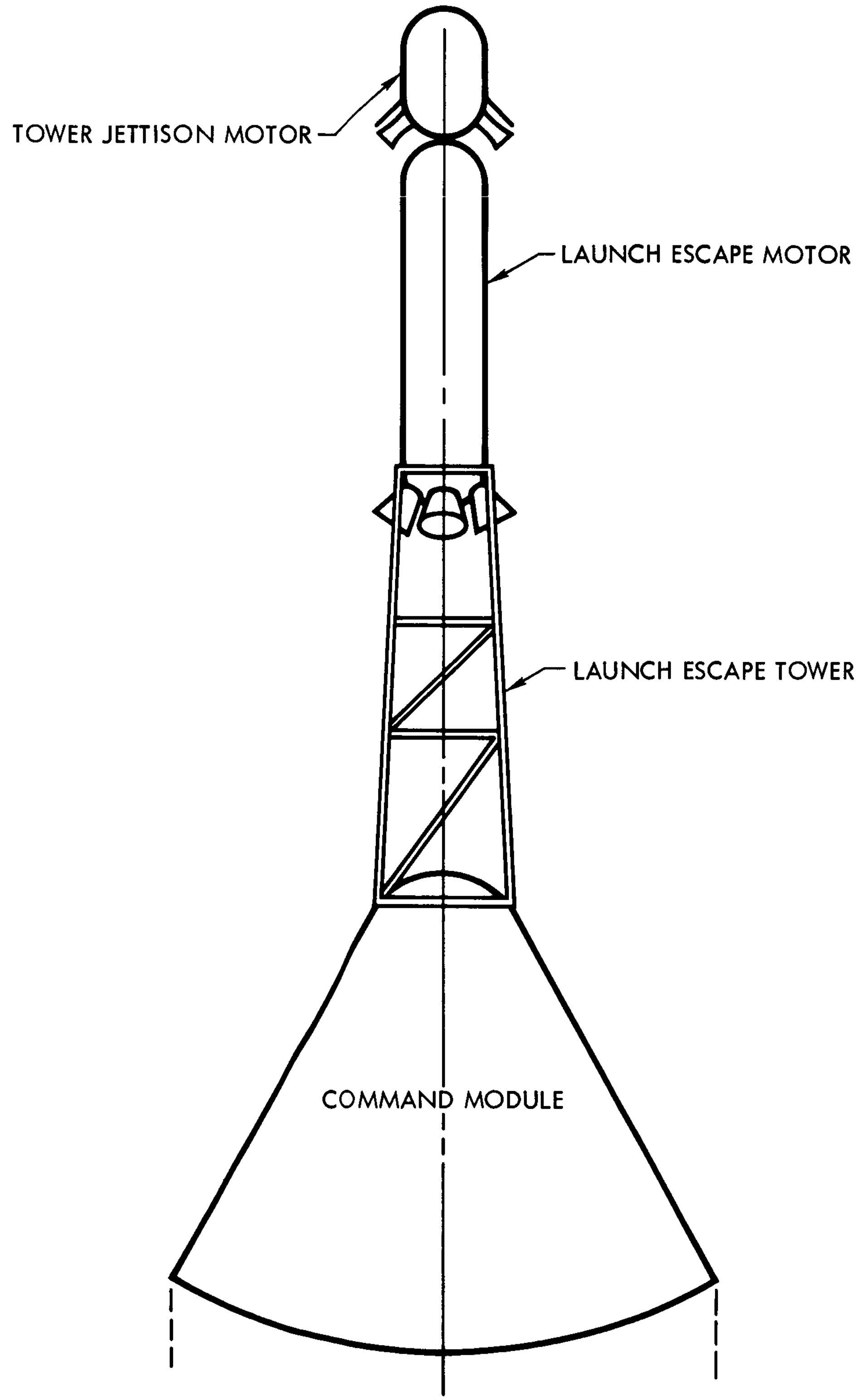

Figure 1. Launch Escape System Arrangement

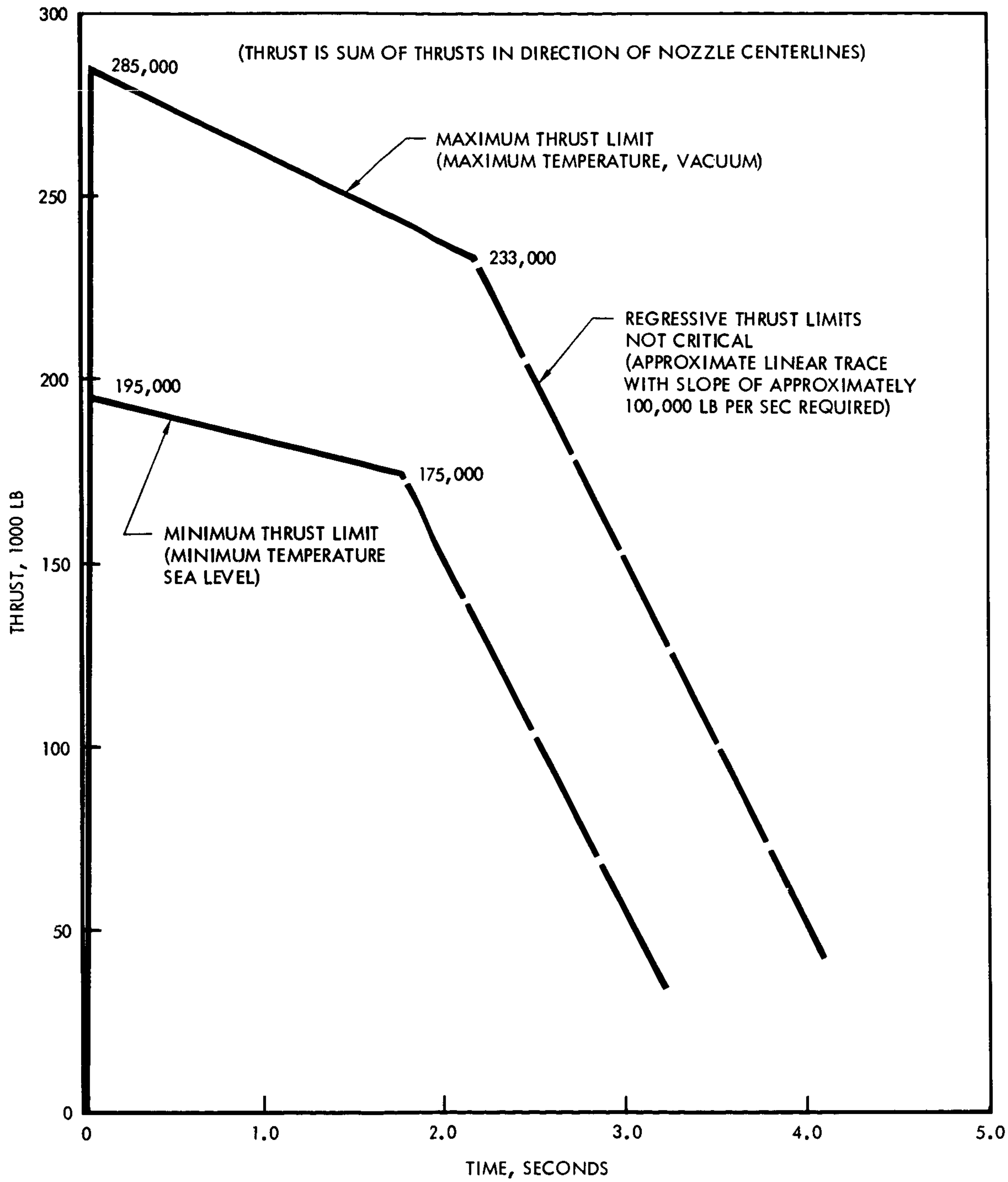

Figure 2. Apollo Launch Escape Motor Thrust-Time Limits

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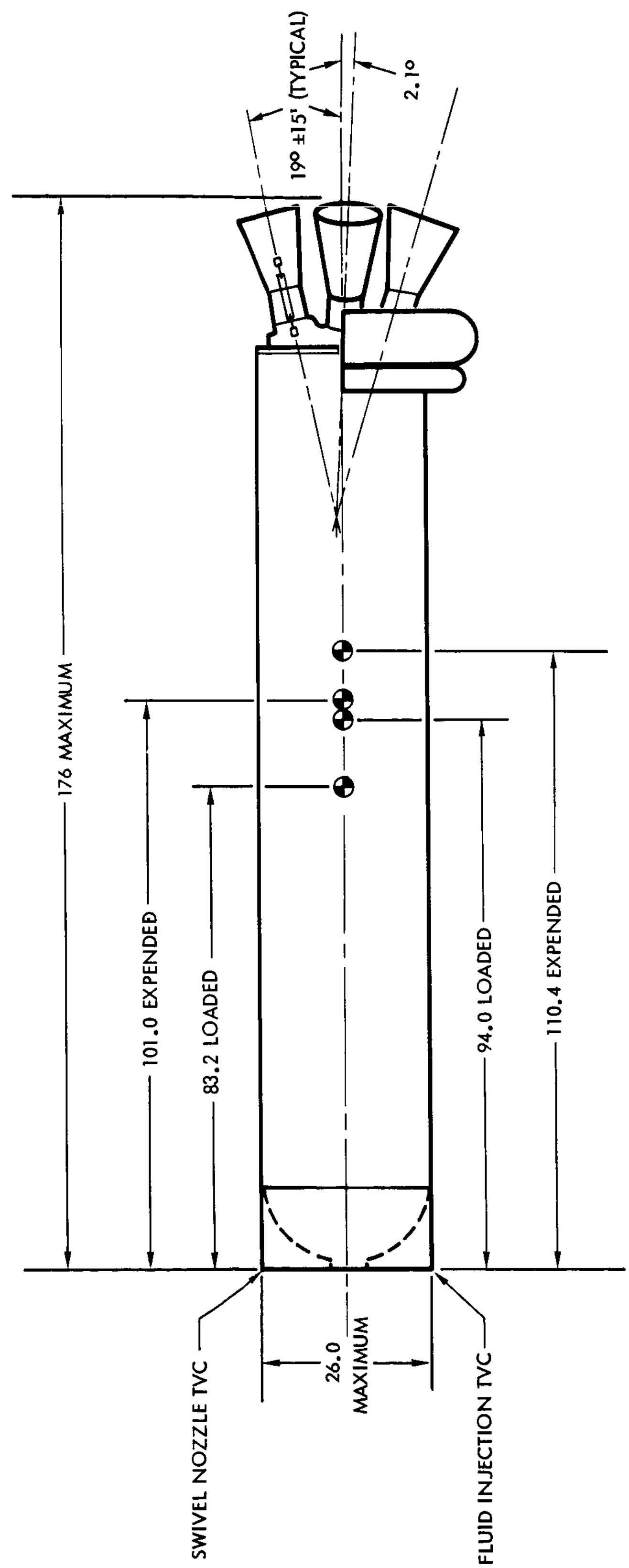

Figure 3. Launch Escape Motor

[redacted]

ENVIRONMENTAL CONTROL

A preliminary list of instrumentation requirements for SA-9 and SA-11 has been completed.

Pressurization and depressurization rates for the command module and the air lock have been established for launch, normal emergency, and re-entry conditions.

A checklist of controls and displays has been prepared to determine the status of the planned display unit.

A display panel arrangement layout for the soft mockup was prepared. Ground rules for cabin interior illumination were also prepared. A drawing of the compartment-crew arrangement was released 13 February. Work was completed on the command-module size and shape study.

Life Systems requirements have been accomplished for Mockup No. 1; and follow-up, to aid in meeting the scheduled completion date, is in progress.

The compartment-crew arrangement drawing and Apollo crewman layout (10th and 90th percentiles) were released 16 February 1962.

Preliminary system installation layouts are in progress. Design of inlet and outlet air-flow snorkels is in progress.

Design work is in progress for support of mockups. A design study of ECS components to determine optimum system integration and component compatibility with system performance requirements is underway.

ENVIRONMENTAL, SUPERCRITICAL GAS STORAGE

Material studies have been made to optimize system weights and configurations.

A study of gas storage requirements (ECS and electric power), on the basis of two identical containers for each gas, has been completed.

[redacted]

PLANNED ACTIVITIES

Preparation of comprehensive design layouts for the fabrication of environmental control system mockups will be initiated.

Design layouts and installation of radiator and heat pumps will be started.

Trade-off studies of dual cryogenic storage vessels versus single vessels are planned.

Request for quotations for solar simulation and the additional space-environmental simulation equipment and instrumentation will be completed.

The life-support forecast for March is as follows:

1. Completion of design-criteria manuals
2. Work-space analyzer fully equipped and in operation
3. Space-suit procurement from subcontractor for latent-heat and area studies
4. Study and investigation of need-for-use of Apollo ejection seat
5. Establishment of preliminary space menu for 14-day mission

[redacted]

[redacted]

EARTH LANDING SYSTEM

PARAGLIDER RECOVERY SYSTEM SUPPORT

The Parachute Subsystem Procurement Specification has been released. Preliminary interface problems have been discussed with Radioplane, and design studies are underway.

The system operational envelope is under study by S&ID and Radioplane. Layout studies of volume requirements for the command module forward compartment and the parachute system have been initiated.

Radioplane, with Douglas Aircraft support, is studying the feasibility of using a C-133 aircraft as a drop vehicle for parachute system qualification tests.

IMPACT ATTENUATION SYSTEM

A trade-off study, conducted by S&ID and Radioplane, evaluated various command-module impact attenuation systems that are compatible with parachute recovery. The systems which have been considered are air bags, crushable structure, retro-rockets, and shock struts. Each of these systems has been evaluated from the standpoint of landing characteristics, weight, volume, cost, schedule, reliability, complexity, and maintainability.

CREW COUCH IMPACT ATTENUATION

The design approach to the crew couch has involved a system of shock struts mounted in the three principal axes between the center-couch structure and the outboard-couch inner edges; to give continuity to the side-couch crossmembers, the center couch structure will include detachable beam cap ties.

A study was made in which vertical load struts were located below the couches and above the couches. Preliminary mockup indicates that the latter does not seriously affect crew vision or convenience.

The head-to-foot attenuation in this concept will be achieved by shock struts mounted below the shoulder area of the couch and anchored to structural rails to permit the struts to translate through the vertical strut stroke range. Side attenuation would be accomplished by means of opposed, single-acting shock struts on the outboard couches, which apply rollers against a reacting surface on the equipment bay closures.

For crew sleep, the center couch will be stowable under a side couch. If strut clearances permit, it will be desirable to hinge the outboard couches down and outward to facilitate crew movements. Kinematics studies to accomplish this are underway.

LANDING IMPACT AND STABILITY STUDIES

Preliminary analyses of the impact and stability phases of earth landing were conducted for several types of impact attenuation systems, including air bags, crushable materials, oleo struts, and retro-rockets. Parameter variations included horizontal and vertical velocity, capsule orientation, and allowable deceleration. The digital computer program used for these studies is being modified to permit more accurate treatment of the oleo strut system. Also, work has been started on the equations of motion for the water impact and stability study.

PLANNED ACTIVITIES

The Mechanical, Dynamics, and Life Sciences groups are working with NASA to finalize landing-shock attenuation rates and magnitudes, so that shock-strut load-stroke curves can be determined.

COMMUNICATION SUBSYSTEM

ANTENNAS

In a meeting held with NASA personnel at S&ID, it was agreed that S&ID would have prime responsibility for the procurement of the R & D spacecraft antennas. R & D antenna-system configurations and locations were tentatively agreed upon, and work began on the preparation of antenna specifications incorporating MSC requirements.

The relative merits of a C-band phase-wobbulator and a dual beacon system were discussed with NASA personnel. The dual beacon system was recommended for present use on the R & D program. Further study should indicate whether the phase wobbulator will adequately provide the required coverage.

Possible radio landing aids were discussed in a meeting with Collins personnel at S&ID.

MEASUREMENTS

A preliminary S&ID measurement requirements list is being reviewed for removing redundancies, standardizing nomenclature, and deleting unnecessary requirements. The NASA R & D instrumentation system was studied in relation to this preliminary list and, along with some additional R & D measurements, is being integrated into the S&ID list.

Analysis of an optimum, standardized voltage level for all measurement systems has been continued, emphasis being on the measurement requirements established to date. PCM telemetry multiplexing was examined in view of different input signal levels. Current transistor state of the art permits reliable usage of the 250-mv data signal level. The programmer design for the PCM telemetry system has been investigated in light of system flexibility and expandability. PCM synchronization methods are being investigated so that an optimum method of providing the reliability needed for real-time data presentation in earth facilities can be determined.

MODULATION AND R-F TECHNIQUES

A comparative analysis of modulation techniques for voice, telemetry, and TV communication is being continued. Communication of real-time TV simultaneously with voice and telemetry has been shown to be feasible when transmitted by any one of several analog means.

A meeting was held at JPL, on 19 February, to brief S&ID, Collins, and NASA personnel on JPL's work on Ranger, Surveyor, and Mariner TV, and DSIF transponders and facilities.

TELECOMMUNICATIONS EQUIPMENT

An additional review of tape recorders has been directed towards determining the compatibility of the NASA R & D recorder with operational requirements. Several presentations by recorder suppliers were monitored at Collins Radio.

An investigation into a means of video bandwidth reduction has been proceeding parallel to a review of existing and planned space-TV systems. Effort has been concentrated on a single means of bandwidth reduction (i. e., simple filtering, reduction of frame rate, and reduction of the number of vertical resolution elements).

PLANNED ACTIVITIES

Intensive efforts will be made to firm the measurement requirements list for all early test vehicles and to determine basic ground rules for transducer evaluations and selection.

Meetings with NASA are planned so that the interface for all NASA-furnished R & D instrumentation systems and their installation design criteria can be clarified and established.

A study of the telescope requirement will be started, and the study of recorders will continue.

A basic time code for the clock will be determined. Signal conditioner standardization will be analyzed for achieving optimum in-flight maintenance and data-channel patching capability. Calibration requirements will be determined for the PCM telemetry system. Integration effort will be extended to ensure that the clock, signal conditioners, calibration system, and data system controls are compatible with overall instrumentation system requirements.

Investigation of an optimum synchronization method for the PCM telemetry system, including ground operational support system (GOSS) and operational requirements, will be continued.

[redacted]

Resulting from an investigation into radio-command, guidance, and display needs, up-data-link recorder requirements will determine whether or not a digital up-link is required.

Studies to optimize the design of R & D and operational antenna systems, including further pattern testing, VSWR measurements on the discone antenna, and evaluation of possible alternatives, will continue.

[redacted]

NAVIGATION AND GUIDANCE INTEGRATION

SYSTEM ANALYSIS

Facility and associated equipment requirements for the Navigation and Guidance (N&G) systems laboratory have been prepared.

A preliminary study has been made of the MIT midcourse-guidance approach. Accuracy, reliability, and fuel-conservation implications are being analyzed.

A study is being made of the MIT computer to determine its characteristics and applicability to various spacecraft functions. Its logic and operational organization are being studied to determine applicability to the guidance computer and compatibility of the interface tie of the subsystems in control, display, and checkout. Study is also being conducted to represent the computer operation and performance, by the transform approach, in planned system-simulation exercises of the spacecraft.

NAVIGATION AND GUIDANCE SYSTEM

An MIT N&G system installation proposal is being compared with the present installation. An alternate approach that would satisfy all requirements and incorporate the desirable aspects of both is being sought.

Required measurement lists for SA-7 and SA-10 are being prepared.

Guidance partials relating lunar-boost and midcourse errors to earth re-entry errors have been computed.

STABILIZATION AND CONTROL SYSTEM

A study has been initiated to resolve the diverse power requirements of the guidance and control systems. Also being investigated is the adequacy of the NASA master clock, designed for early flight tests, as a combined guidance-and-control time reference.

PLANNED ACTIVITIES

Trade-off of sensor accuracies versus fuel weight, for rendezvous and lunar-landing sensors will be performed. Interactions between sensor configuration and spacecraft design are to be determined.

[redacted]

[redacted]

Study of master clock and power requirements for guidance and control systems will be continued.

S&ID will determine the performance of different methods and techniques for processing spaceborne-derived data.

Studies of various N&G equipment installations will be continued.

Preparation of the subsystem specification will be started.

Computer input, output, and other typical program requirements will be studied.

[redacted]

[redacted]

COMMAND-MODULE STRUCTURE AND SUBSYSTEM INSTALLATION

BOILERPLATE ARTICLES

Tool fabrication was started for initial boilerplate command modules. To meet weight restrictions, structural steel will be used for the aft bulkhead only. The crew compartment and forward bulkhead structure will consist of welded aluminum.

PHOTOTYPE COMMAND MODULES

Brazed-honeycomb heat-shield development studies continue with the investigation of zone-brazing methods.

STRUCTURAL ANALYSIS

An L-605 alloy, brazed-honeycomb panel (16 by 36 in.), fabricated by NAA, Los Angeles Division, was tested under combined load and temperature in the radiant heat facility. Analysis has not been completed.

A report was completed on the compatibility of structural materials, fuels, and oxidizers for propellant tank design. Tank fabrication techniques, cleanliness of tanks, the water content of N_2O_4, and methods of removing water were also outlined.

In support of the Apollo Test Program, Phase-III, physical metallurgy analysis was made on L-605 alloy, brazed-honeycomb panel No. 3, subsequent to bare panel testings. Panel failure mode was determined to be located in core-to-face braze.

An evaluation was made of mechanical properties at room temperature, 500, 1000, 1500, 1800, and 2000 degrees F of HS-25 cobalt-base alloy-honeycomb. Tensile tests were run on the skin. Tensile, block-shear-flatwise, and edge-compression tests are being run on the honeycomb composite.

Phase-I (the determination of material properties for phenolic-chopped-nylon fabric ablative and aluminum-honeycomb sandwich substrate) and Phase II (the combined 50-Btu-per-sq-ft-per-sec radiant heating, with structural loading evaluation of a 16-by-36-inch, composite, ablative-substrate specimen) were completed on schedule.

[redacted]

[redacted]

Phase-III effort is limited to specimen preparation of the ablatives and assembly operations of the composite. These efforts have been held to schedule. Significant developments include (1) the molding of ablative profile thermocouples (36 gage) into such diverse materials as phenolic-chopped nylon and silica fabrics and rovings, nylon powder and fibrous microballoons, and (2) the formulation of a 25-lb-per-cu-ft ablator with excellent mechanical properties.

WEIGHT ANALYSIS

Weight and volume trade-offs have been made for a configuration of various conical, taper, and corner radii. All systems component weights are being reviewed to establish a firm, minimum-weight module. Centers of gravity have been determined for some configurations with different equipment allocations. Cost analysis weight data is being revised to incorporate current weights.

STRUCTURAL TESTS

Preparations are underway for a composite panel test. The structural panel will be a 16-by-36-in., L-605 brazed-honeycomb panel. Ablative material will be attached to the structural panel. The composite panel will be loaded for bending and the ablative for shear. A heat flux of 50 Btu per square foot per second will be applied to obtain an interface temperature of 500 degrees F.

INNER STRUCTURE DESIGN

A study is now investigating methods of increasing the volume available for the crew and equipment within the command module encompassing the following:

1. Locally rearranging the internal structure and equipment

2. Modifying the corner radius and the back angle

3. Expanding the basic diameter of the module (with the same proportional back angle and corner radius)

A preliminary internal rearrangement has been developed along the ground rules of the first study. This configuration will be compatible with the S-IV booster and will allow the greatest probability for target-weight achievement.

OUTER STRUCTURE DESIGN

The J. J. Foster, Stresskin, material-evaluation program has been initiated; its purpose is to determine the feasibility of using welded honeycomb for the outer structure. The first phase of the program will be to establish design and manufacturing criteria and to determine the ability of J. J. Foster to produce and deliver on schedule.

HEAT-SHIELD STRUCTURE

Test-panel drawings reflecting the aft- and forward-compartment heat-shield configurations were completed, and the test panels have been ordered.

The forward heat-shield shroud operating mechanism has evolved into a configuration that has resulted in the saving of considerable space in the parachute compartment. A trade-off study is in progress to determine whether a dual electric motor drive or a hand-operated system would better satisfy the requirements of sealing and weight.

Further studies, utilizing a system of links and bellcranks, are being made to determine whether a lighter system that still will be compatible with the space requirements can be devised.

SYSTEM EQUIPMENT INSTALLATION

Representatives from the MIT Instrument Laboratory submitted their proposal for the preliminary location of the guidance and navigation equipment. They advocated a duplicate system of their equipment that would permit installation in either the left- or right-hand equipment bays. S&ID prefers a single system installed in the lower equipment bay. Layouts are being made for both versions, and the weight, volume, and structural (penetration of the heat shield) requirements are being evaluated.

Basic load paths and umbilical connections between the command module and the service module have been chosen. Moment loads will be reacted by three tension ties from the service module, two of which will contain umbilical connections. Six compression pads will react longitudinal (boost) loads, and six radial-bearing pads (three of which are part of the three-tension ties) will react lateral shear loads. Tension ties are pretensioned to prevent load reversal, and all bearing pads are adjustable to fit the command-module surface variation.

During February, investigations were made of requirements for simulating space environments for materials evaluation.

[redacted]

CREW COUCH

Numerous problems and interferences have arisen, causing the couch to be repositioned and redesigned. The present design indicates the use of a hand controller, similar to that used on the X-15 vehicle, which can be adjusted to accomodate a man in the 10th to the 90th percentile. In turn, the hand controller will be attached to the arm rest, which is also adjustable. The couch-seat-to-back angle can be repositioned, within a limit of 107 to approximately 140 degrees, without disconnecting the armrest. Beyond this point, a disconnect will have to be performed.

Although the early design indicated a headrest interference with the inner mold line, a redesign of the headrest and couch structure eliminated this condition. The headrest is adjustable for approximately a four-inch excursion. The side support to the head has been limited, for couch-module clearance. The foot controller has been integrated into the couch-leg support, with a fold-up capability. A foot or leg adjustment has been incorporated in the leg support, so that the couch can accomodate the various sizes in crew members.

One couch will fold out to a sleep position and stow under either of the other couches located in the mid-course position with allowance for a man to turn over. The present couch design, incorporates stowing of the couch, the crewman parachute, and survival kit.

The main problem areas are the ability of the crewman to move about to remove the center couch and the clearances required for the specified couch mission positions.

CREW ACCESS HATCH

In the choice of a hatch mechanism, a trade-off study is indicated wherein weight, complexity, and reliability must be balanced against crew survival requirements. Weight studies are being made of the various systems (i.e., jettison or manual hatch removal, etc).

AIRLOCK AND DOCKING PROVISIONS

Numerous configurations have been considered for the airlock; these have been considered along with the necessity of docking the command module with other vehicles. These configurations are based on lightness, adequate sealing, simplicity of operation, and ease of manufacture.

[redacted]

STUDIES

A study pertaining to dynamic and static seals for the airlock is being initiated; its purpose is to establish material feasibility in relation to the allowable leakage rate and environment. National Research Corporation has conducted programs for sealing to a vacuum side. Their capability in this technical area is of interest.

Studies are continuing on the requirements for wiring and ducting routings within the crew compartment; and a study has been started to define a wiring harness system that would be accessible in case of modifications or changes and would allow a modular concept for the electronic packages.

A brazing-alloy study is being made to evaluate the compatibility and reliability of a Coast Metal proprietary-foil alloy for brazing Rene '41 alloy honeycomb structures.

A weld-variable study was conducted to determine the optimum process for welding 2014 aluminum alloy.

Thermal conductivity and specific heat studies in the 150 to 750 degrees F range are being run on a candidate ablation material. This material consists of phenolic-nylon resin, with microballoon as filler.

Studies were initiated to determine natural frequencies and modes for the escape rocket and tower, which are considered to be cantilevered from the C-1 booster and also part of the C-1 with the SA-5 vehicle if tower frequencies are in the range of lower-booster, bending-mode frequencies.

ENVIRONMENTAL CRITERIA

Noise levels were calculated for several flight conditions, including normal launch and flight, re-entry, pad abort, and abort at maximum dynamic pressure. Outlines were made on estimated vibration levels caused by maximum acoustic excitation during each of these flight conditions. Measurement programs and instrumentation requirements to substantiate vibration, acoustic, and shock environmental predications were prepared.

PLANNED ACTIVITIES

One more base-panel test on a structurally sound panel is being considered to prove or disprove the structural integrity of the panels.

The following activities are also programmed for the next reporting period:

1. Completion of Phase-III effort

2. Extension of lab ablator formulation to 500 F service

3. Cursory study of low-pressure molding formulations

4. Development of thermal and mechanical property data for preliminary ablative material

5. Fabrication of test panels to continue evaluation of the Coast Metal brazing alloy

6. Additional metallurigical studies on ablative-coated panels of the Phase-III program

7. Metallurgical studies to support the evaluation of J. J. Foster Stresskin structural reliability and fabricability

8. Continuation of the screening evaluation studies of these companies and Government agencies currently working with dynamic seals for space environments

9. Study of the prior work performed on the impact sensitivity of N_2O_4 and titanium, with special emphasis on water content and foot-pound load for sensitivity

Production orders for material withdrawal and detail fabrication are presently being prepared; actual structure fabrication will begin next month.

[redacted]

SERVICE PROPULSION SUBSYSTEM

SYSTEM SUPPORT

An equipment hardware list covering the types of components that will be used in the propellant systems was established. Equipment specifications are being prepared to procure those items listed.

ROCKET MOTOR

During this period, a study was conducted to determine the number of engines to be employed for the service propulsion system. The study included consideration of such items as system reliability, vehicle performance, vehicle complexity, engine development, control system requirements, and weight. On the basis of this study, it was concluded by S&ID that a single engine was the optimum approach.

Results of the aforementioned study were presented to NASA personnel (Table 5) at the Houston Manned Spacecraft Center (MSC) on 7 February. Various aspects of the study were discussed, and NASA personnel agreed to the proposed issuance of an S&ID work statement to initiate procurement of an engine for the single-engine configuration. A joint agreement was reached: S&ID would continue to study both configurations and would advise NASA if the study should indicate the desirability of a change to the multiengine configuration.

During the discussions at Houston, the thrust level of the single-engine configuration was reviewed, and agreement was reached on a vacuum thrust level of 20,000 pounds. This thrust level will maintain a thrust-to-weight ratio of 0.4 and allow a considerable increase in the lunar liftoff weight of the spacecraft.

On the basis of a single-engine configuration, a preliminary Statement of Work for the Tower Jettison Subcontractor (SID 62-19) has been prepared; it defines the requirements established to date. The general design and performance requirements specified are presented in Table 3.

[redacted]

[redacted]

Table 3. Design and Performance Requirements, Service-Module Propulsion Engine

Item	Requirement
Thrust	20,000 pounds
Propellants	Hypergolic
Fuel	50-50 UDMH - N_2H_4
Oxidizer	N_2O_4
Supply system	Pressure fed
Supply pressure	175 psia maximum
Specific impulse	315 seconds (minimum)
Mixture ratio (O/F) chamber	2.0 ±1 percent
Cooling	Ablation
Pressure	100 psia
Nozzle	Removable
Cooling	Radiation
Restart capability	50 minimum
Duty cycle	
Minimum	1.0 seconds
Maximum	500 seconds
Service life	750 seconds
Mounting	Gimbal
Control	Non-throttleable
Weight	375 pounds maximum
Reliability	0.99991

[redacted]

PROPELLANT SYSTEM

A plan of action has been initiated to evaluate seal and bladder materials for the N_2O_4-UDMH/N_2H_4 propellant system. The Stillman Rubber Company and Goodyear Tire Company appear to have an established capability in the materials and processing technology of bladders and seals for such systems.

Gas detection, monitoring, and location studies are being firmed up. These studies will include methods; system; location of gages; and evaluation for simplicity, ease of operation, accuracy, and sensitivity.

Certain plastic compositions that are eminently suited for positive expulsion bladder requirements, from a compatibility standpoint, are to be evaluated under a detailed program, which has been prepared.

Studies of several propellant-system tank configurations were continued. These configurations are identified as toroidal tank (Figure 4), quadruple tank with isolation provisions (Figure 5), quadruple tank with simplified system (Figure 6), and dual tank with simplified system (Figure 7). Factors considered include weight, number of components, number of leak points, center-of-gravity management, in-flight test and maintenance, service maintenance, and tank fabrication difficulties. These studies resulted in prime consideration being given to the dual tank with simplified system arrangement (Figure 7). Design layouts are proceeding with this configuration to establish the general locations of system equipment and plumbing.

PLANNED ACTIVITIES

Design layouts will be started for the preliminary engine flight-rating test stand. The prototype system layouts will be used with the system components located in the test stand essentially as they will be in the prototype modules. Off-the-shelf hardware will be utilized, wherever necessary, and design layouts will be modified to adapt to the substitute equipment. Studies will be made to determine the optimum system arrangement for the service propulsion subsystem tank configuration selected.

An analytical study will be conducted to determine the extent of orbital flight variation that could be caused by temperature variations, tank pressure variations, etc. From this study, the design requirements for a propellant utilization system can be determined.

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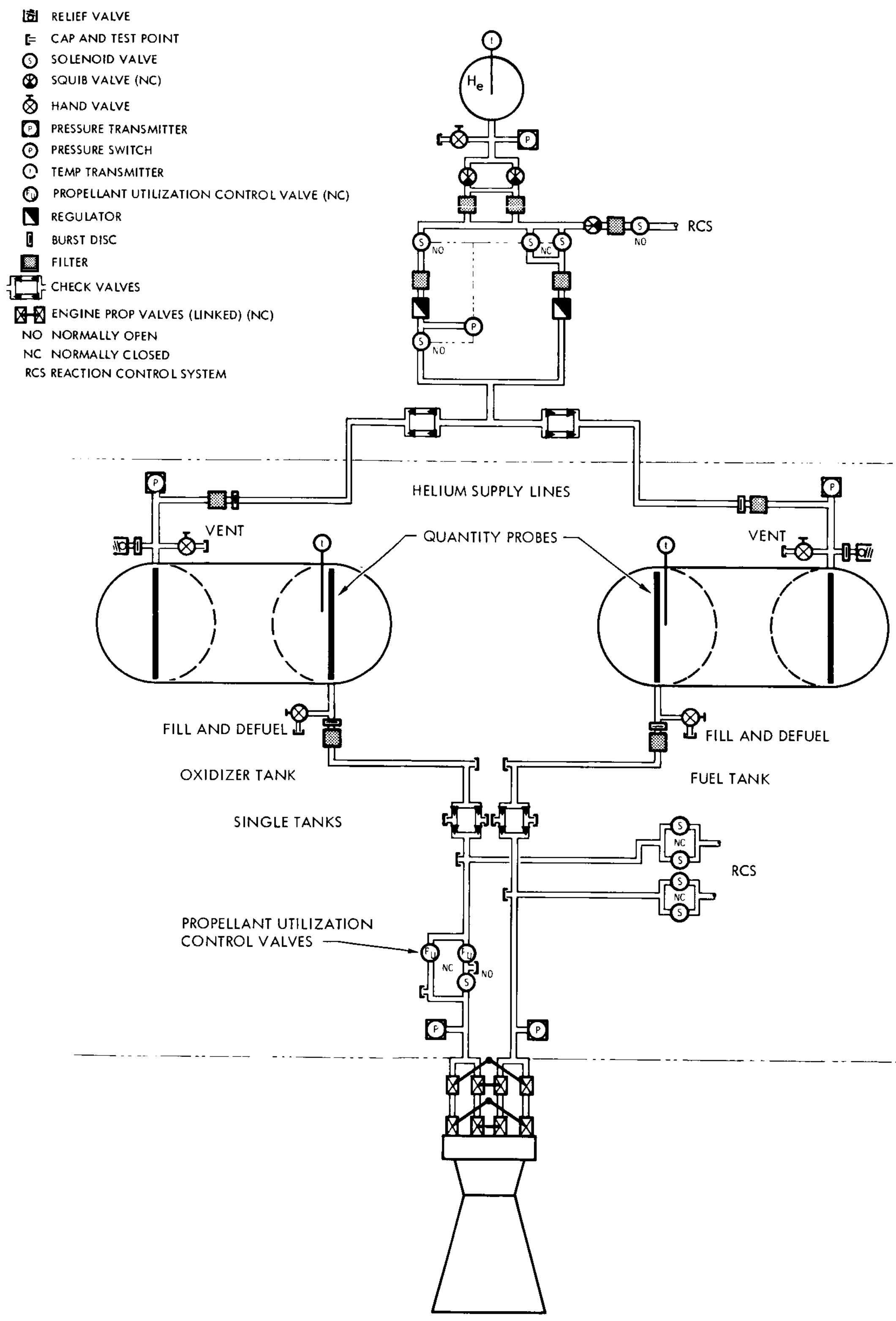

Figure 4. Propulsion System, Single Engine - Single Tank

[redacted]

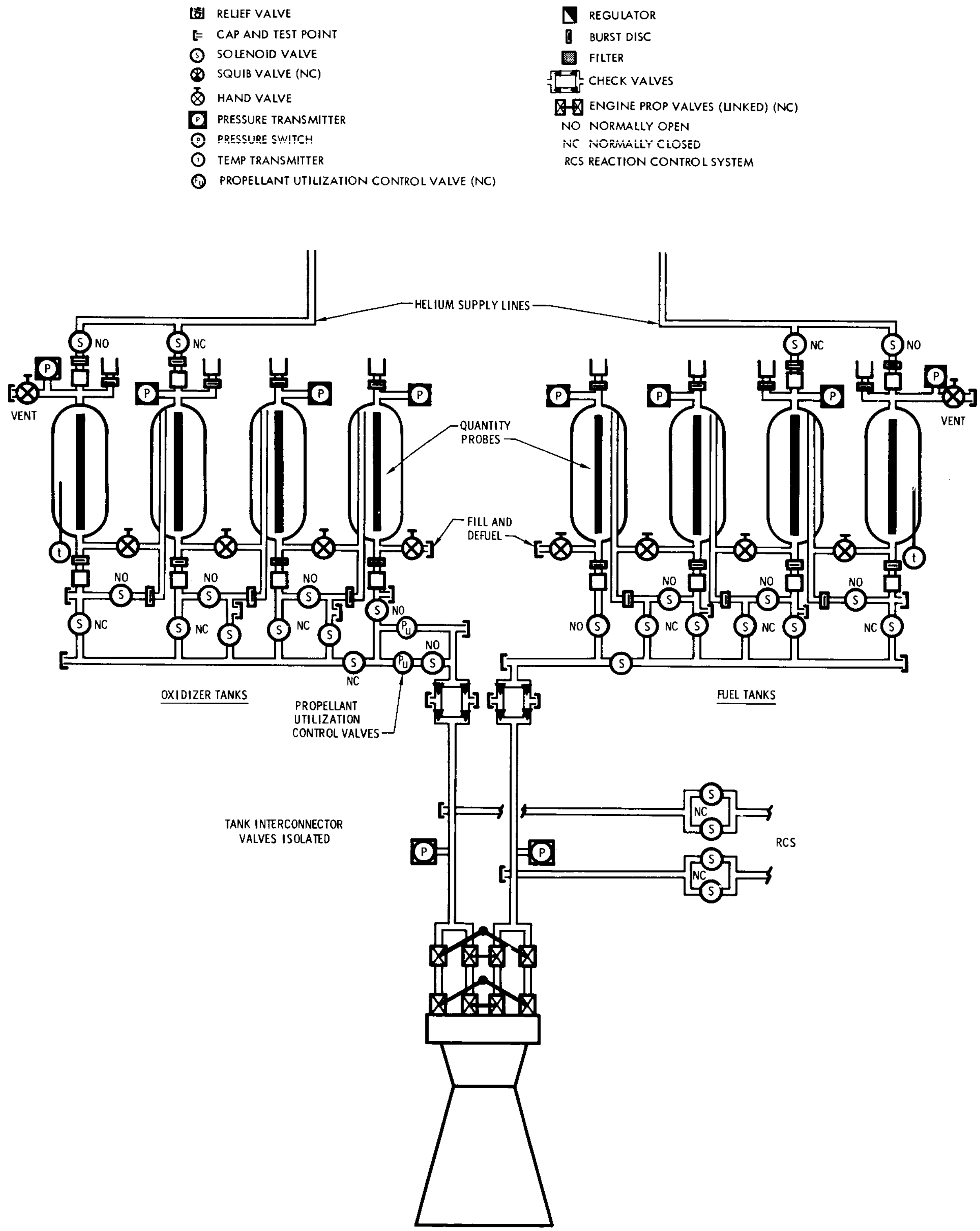

Figure 5. Propellant System, Multiple Tanks - Single Engine

[redacted]

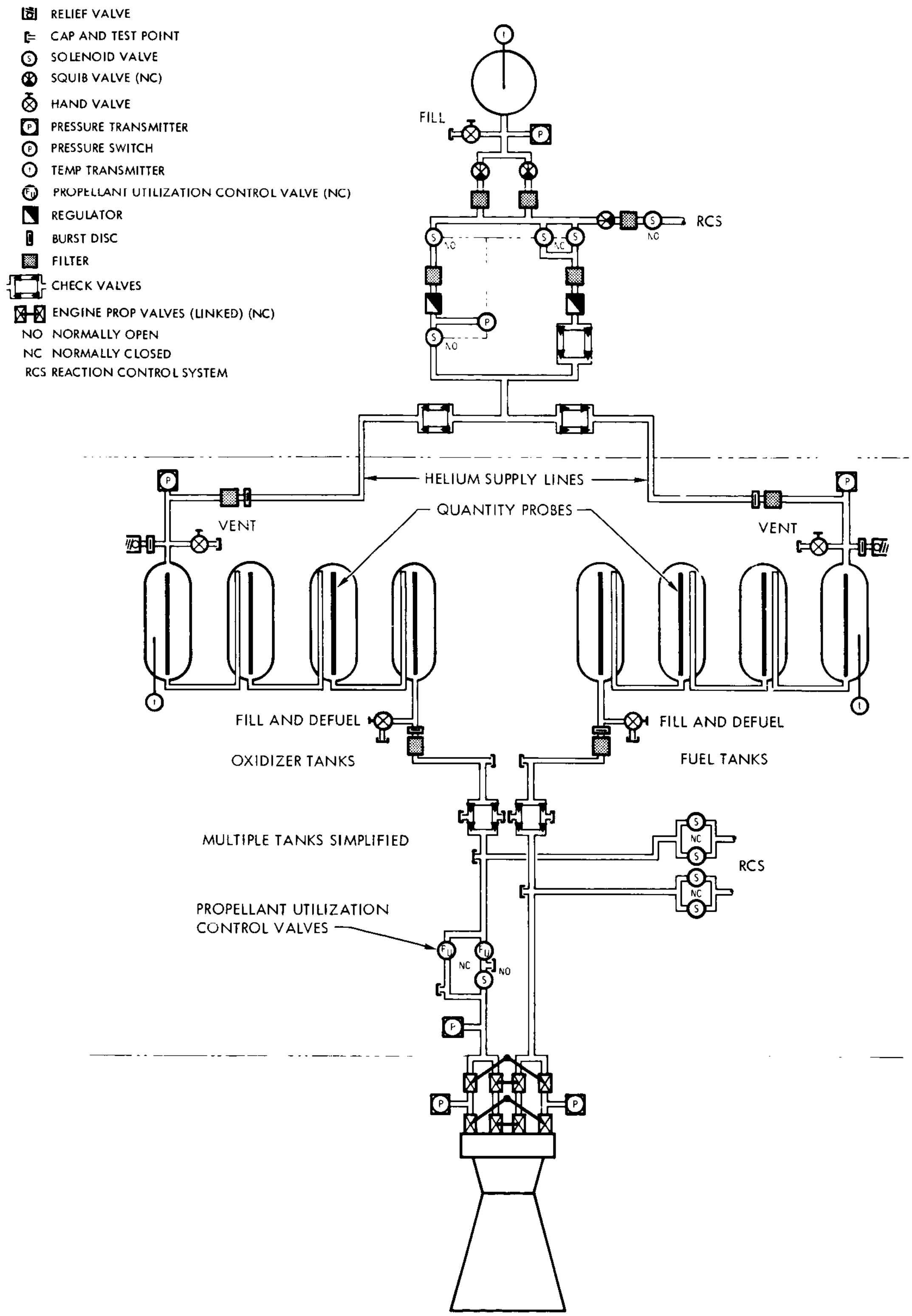

Figure 6. Propulsion System, Multiple Tanks - Single Engine

[redacted]

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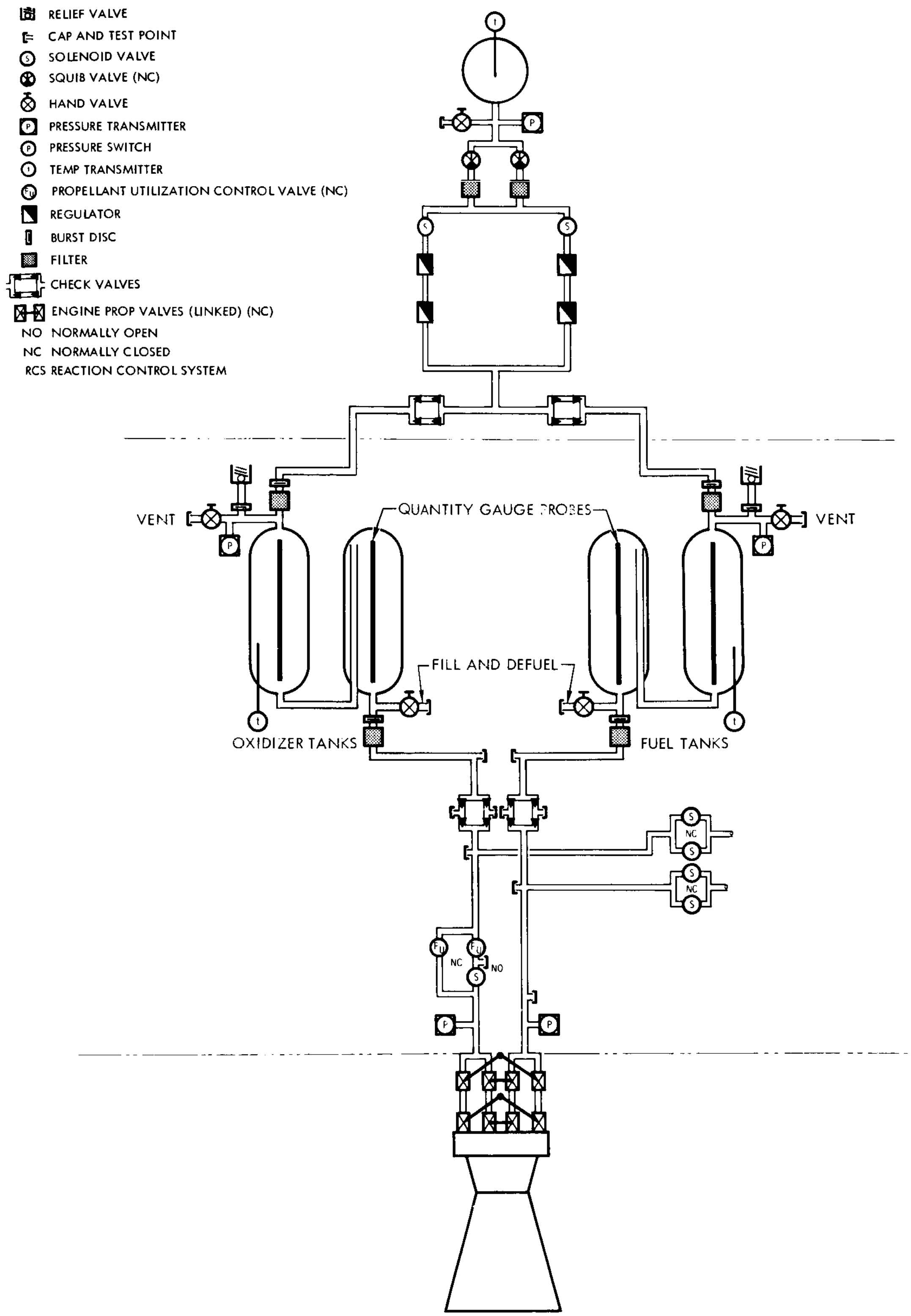

Figure 7. Propulsion System, Dual Tanks

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Other programmed activities are as follows:

1. A welding-variable study, to determine the integrity of pressure vessels fabricated from proposed materials, titanium, 6 Al - 4 Va alloy and/or H-11 hot die steel

2. Continued evaluation of various welding designs, in support of the projects

3. Initiation of a mechanical properties study of various inert plastic-faced composite films

4. Initiation of a study of methods of joining composite films

5. Completion of the area and instrumentation investigation

6. Investigation of testing requirements

7. A study of other sources that are evaluating and/or using seals and bladders (e. g., JPL, Lockheed, Aerojet, Martin, and Rocketdyne)

SERVICE-MODULE STRUCTURE AND SUBSYSTEM INSTALLATION

STRUCTURAL ANALYSIS

Preliminary material properties for candidate pressure-tank materials and their compatibility with various fuels and oxidizers have been determined. Because of its high strength-to-density ratio and compatibility with the selected fuels and oxidizers, titanium appears to be the best pressure-tank material.

Assessments have been made on the effects of full gimbal at maximum dynamic pressure, first stage, and boost on the basic structure is increased shear-and-bending moments. The problem of positive hold-down of the command module became more severe because of this gimbal condition.

The feasibility of various methods of fabricating a high-pressure, helium-storage tank is being investigated. Vendors contacted to date agree that the fabrication techniques required for this size of titanium tank are beyond the state of the art, and development work will be required.

Component structural configurations, candidate materials, and gauges have been furnished to the weights unit for cost-estimating purposes.

Basic load paths between the command module and the service module have been established.

WEIGHT ANALYSIS

In an attempt to achieve minimum weight, weight trade-offs are being generated for various structural configurations. The configuration studies include engine location to achieve minimum length in the service module, at the expense of a longer adapter.

Revision of the cost-analysis weight data is being based on current weights.

TANK STRUCTURE DESIGN

The design review board chose a single-engine multitank as the configuration for the Apollo vehicle. The propellant tanks are sized for a spacecraft gross weight of 49, 850 pounds. The tanks will be off-loaded for alternate missions. Two each of the fuel and oxidizer tanks have been recommended as a suitable arrangement.

In response to the tank requirements for service-module fuel, oxidizer, nitrogen, oxygen, and helium, as delineated by the Apollo structures and propulsion groups, a study was initiated to assemble pertinent data on plastic tank constructions.

PLANNED ACTIVITIES

The possibility of weight reduction through a more efficient utilization of the structure is being investigated.

Utilization of the outer shell for body axial, shear, and bending loads will be investigated. This condition imposes the requirement that the access doors be structural with respect to inplane shear and axial load.

Additional data will be compiled on fracture characteristics (e. g., notched-to-unnotched ratio, strength-to-weight ratio) for structural materials at cryogenic temperatures.

Test-equipment specifications will be completed. Materials test plans will be prepared. Tank requirements will be defined.

Selection (as a basis of calculation) will be made on specific designs, modes of fabrication and materials for each tank.

Calculation of nominal tank weights and comparison with nominal weight obtained by other materials (titanium and aluminum) will be made.

ELECTRICAL POWER SUBSYSTEM

ELECTRICAL POWER DISTRIBUTION

Preliminary system schematics, wiring provision drawings, and weight breakdowns have been prepared.

The investigation of ribbon, tape, and etched circuits versus standard wire bundles has disclosed advantages and disadvantages in each method. The value of the afforded weight and reliability may be offset by the lack of available hardware. It appears that the earlier vehicles will employ conventional methods, with the newer schemes phasing in as hardware can be made available.

An investigation of the use of automatic computation methods for developing wiring diagrams indicates that they promise overall labor-saving methods but tend to increase engineering work loads.

PLANNED ACTIVITIES

An effort is underway to reduce the tentative total load of 500 kwh, and to integrate the a-c, non-precision power requirements into one inverter, to reduce weight and r-f noise problems. During March, all test equipment specifications will be completed, and the materials test plans will be prepared.

REACTION CONTROL

COMMAND-MODULE AND SERVICE-MODULE ENGINES

Preliminary work statements for the command- and service-module reaction-control engines were completed during this report period. Detail requirements for the two engine configurations are summarized in Table 4.

DESIGN

Preliminary work has been started on the breadboard design for the reaction-control systems. A complete system for the command module and the service module will be assembled, on a development basis, to determine overall system compatibility, propellant servicing, checkout, and operation.

PLANNED ACTIVITIES

An investigation will be made of the complete area and instrumentation requirements for the laboratory fluid system.

Table 4. Command and Service-Module Reaction Control Engines Specification Requirements

Item	Requirement	
	Command Module	Service Module
Vacuum thrust level	100 ±5 lb	100 ±5 lb
Vacuum specific impulse		
Less than 1 second	295 sec	295 sec
Greater than 1 second	310 sec	310 sec
Chamber pressure	100 psia	100 psia
Propellants		
Fuel	50-50 UDMH/N_2H_2	50-50 UDMH/N_2H_4
Oxidizer	N_2O_4	N_2O_4
Thrust transient		
Build-up	7.5 ms to 5% 12.5 ms to 90%	7.5 ms to 5% 12.5 ms to 90%
Decay	7.5 ms to 90% 12.5 ms to 5%	7.5 ms to 90% 12.5 ms to 5%
Pulse mode operation		
Frequency	0-25 cps	0-25 cps
Minimum shutdown	10-ms	10 ms
Continuous operation	200 sec	1000 sec
Service life	600 sec	1000 sec
Operational cycles	9000	10,000
Outside wall temperature	200 degrees F	-
Reliability	0.99948/200 sec	0.994/1000 sec

[redacted]

COMMAND-MODULE GROUND SUPPORT EQUIPMENT

SYSTEM REQUIREMENTS

As the result of a requirement investigation, preliminary test plans were prepared for the ground support equipment (GSE) items required for the laboratory fluid systems.

SUPPORT

Investigation of the Aero Spacelines, Inc., modification to the Boeing-377 aircraft for airlift of the S-IV stage indicates that this aircraft would accommodate the Apollo modules if the modification should be carried out successfully. Flight test of the Boeing-377 has been conducted with the fuselage lengthened 200 inches. It is expected that flight tests of an enlarged fuselage configuration will commence within about two months.

STUDIES

Initial studies were completed on requirements for equipment to support Apollo spacecraft tests through Phase A.

DESIGN

A study of fluid system requirements has been initiated in each of the using areas to define storage quantities, pressure, and flow. These requirements will then be fed into the appropriate facility criteria to assist in defining area size and storage requirement for fluids.

Design of the command-module sling for boilerplate No. 1 has been started. In addition, to determine exact requirements for designing handling equipment, the overall handling sequence of the command module, service module, and spacecraft has been initiated.

PACKAGING AND TRANSPORT

A packaging and transport section has been included in the Apollo Support Plan (SID 62-203). This section outlines the transport and preparation-for-delivery requirements of all hardware delivered under the Apollo program.

A packaging and transport section of the Reliability Plan (SID 62-203) has been developed.

[redacted]

PLANNED ACTIVITIES

The formulation of test plans and requirements will continue during the month of March.

Preparation of the criteria for the AMR Operations and Checkout Building is to continue, and data for the various areas will be released as they are completed. The preparation of criteria for the pyrotechnic facility, static firing facility, and other AMR areas will be started in March.

The complete handling equipment design for boilerplate No. 1 will be started during March, with engineering release to be completed in April. Continuing effort is planned for the refinement of handling requirements, with completion of this effort expected during March.

Further effort is to be expended in defining the servicing requirements for all of the spacecraft systems.

[redacted]

SERVICE-MODULE GROUND SUPPORT EQUIPMENT

SYSTEM REQUIREMENTS

Investigations were made of the testing area and additional instrumentation required for the laboratory fluid systems. As a result of the requirement investigation, preliminary test plans were prepared for the GSE items that will be needed.

TRANSPORT

The C-133B transport of the service module remains in question, pending final design configuration. Truck transport capability for delivering the service module has been investigated, and discussions with a carrier indicate that the service module can be delivered to AMR by truck.

PLANNED ACTIVITIES

The formulation of test plans and requirements will continue during the month of March.

GROUND OPERATIONAL SUPPORT SYSTEM

SUPPORT

Information from RCA is presently being incorporated into the GOSS System Performance and Interface Specification (SID 62-76), which was prepared at S&ID for delivery to NASA. This specification details the operational concepts of GOSS, ranging from its identification as a centrally controlled system to finer details, such as individual station operations during simulated or actual missions. Diagrams are included to show the global dispersion of the stations, information flow, and the communication complex. Technical discussions of radar tracking, station site selection, and other related topics are included in the specification appendix.

PLANNED ACTIVITIES

During March, effort will be concentrated on the GOSS equipment performance specifications. RCA will also contribute to these specifications.

FACILITIES

AMR OPERATIONS AND CHECKOUT BUILDING

Layouts of the AMR Operations and Checkout Building have been prepared. A meeting on the S&ID-proposed arrangement was held on 9 February 1962 with NASA personnel. New layouts are being made incorporating the comments made by NASA at that meeting.

Preliminary criteria prepared for the propulsion development facility is being reviewed.

In order to support the current Apollo development schedule within the design and construction time allowable on these facilities, it is mandatory that funding be obtained for the design effort prior to the formal negotiation and approval of the facilities contract.

PLANNED ACTIVITIES

It is anticipated that facilities contract funding will be requested for the following new facilities:

1. Propulsion systems development facility, proposed to be located at Air Force Plant No. 66, McGregor, Texas
2. Systems integration and checkout facility, planned as a major addition to Building No. 6
3. Bonding and test facility
4. Space systems development facility
5. Addition to the existing radiographic facility
6. Plaster master modification and storage facility
7. Data ground station—major modification in Building No. 6

[redacted]

Table 5. Meetings

Subject	Meeting	Location	Date	S&ID Representative	Organizations Represented
Survey of potential subcontractors for Apollo heat shield	1 2 3 4 5	Wilmington, Mass. Philadelphia, Penn. Cinncinnati, Ohio St. Louis, Miss. Dallas, Texas	3, 4 Feb	Gershun Hanifin	S&ID, Avco S&ID, General Electric S&ID, Cinncinnati Test Labs S&ID, Emerson Electric S&ID, Chance-Vought
Coordination with Mercury Recovery Branch for applicability to Apollo	6	Langley Air Force Base Williamsburg, Va.	4 Feb	Smith	S&ID, NASA
NASA coordination on propulsion systems	7	Houston, Texas	6 Feb	Field Gibb	S&ID, NASA
Discussion of Apollo lunar landing module	8	Houston, Texas	6 Feb	Ryker	S&ID, NASA
Evaluation of subcontractor facilities	9 10	Milwaukee, Wisc. Ionics - Boston, Mass.	7 Feb	Nash	S&ID, Allis-Chalmers S&ID, Ionics
Coordination of Apollo wind tunnel program scheduling at Air Force facilities	11	Tullahoma, Tenn.	7 Feb	Bornemann	S&ID, Arnold Dev. Ctr.
Review of operational simulation facility	12	Midland, Texas	12, 13 Feb	Rogers Robertson	S&ID, Chance-Vought
Discussion of Apollo lunar landing module	13	Houston, Texas	13 Feb	Ryker	S&ID, NASA
Discussion thrust vector control of Polaris missile	14	Sunnyvale, Calif.	15, 16 Feb	Field Frederickson Peterson	S&ID, Minneapolis-Honeywell
Discussion of Apollo simulation	15	Columbus, Ohio	15 Feb	Walli	S&ID
NASA briefing	16	Houston, Texas	17-19 Feb	Johnson	S&ID, NASA
Survey of prospective suppliers for Apollo	17 18	Scottsdale, Ariz. Thikol Chemical Co. - Elkton, Md.	18-22 Feb	Jones	S&ID, Rocket Power S&ID, Thiokol Chem. Co.
Apollo survey team	19 20 21	Elkton, Md. Denville, N.J. Mesa, Ariz.	18-22 Feb	Hendricks	S&ID
I.A.S. Symposium: "National Tracking and Command of Aerospace Vehicles"	22	San Francisco, Calif.	18 Feb	Thrope	Symposium (S&ID and interested participating organizations)
Discussion of Apollo program status	23	Houston, Texas	18 Feb	Benner Ryker Corvi	S&ID, NASA
MIT and NASA coordination Apollo navigation and guidance (N & G) interface meeting	24	Houston, Texas	19-22 Feb	Kennedy Dale Risley Campbell	S&ID, MIT, and NASA
Reaction control survey	25	Elkton, Md.	19 Feb	Coleman	S&ID, Thiokol
Buffet problems with Apollo-Saturn C-1 wind tunnel test scheduling	26 27 28	Houston, Texas Buffalo, N.Y. Cleveland, Ohio	19, 20 Feb	Allen Gildea	S&ID, NASA S&ID, Cornell Aero. Lab. S&ID, Louis Research Ctr.
Technical coordination with MSC (NASA aero elastic wind tunnel)	29	Houston, Texas	19, 20 Feb	Stevens Lassen	S&ID, NASA
Ranger, Surveyor and Mariner T.V.	30	Pasadena, Calif.	19 Feb		S&ID, Collins, NASA, JPL
Reaction Control	31	Denville, N.J.	20 Feb	Coleman	
Pre-test conference on Apollo wind tunnel test	32	San Francisco, Calif.	20 Feb	Crowder	S&ID
Simulation coordination	33	Columbus, Ohio	20 Feb	Oglevie	S&ID
Survey of reaction control jets	34	Van Nuys, Calif.	20 Feb	Russo Allen	S&ID, Marquardt Corp.
Environmental control of GSE	35	Los Angeles, Calif.	20 Feb	Curry Stowe Siebel	S&ID, Air Research
Tower jettison	36	Mesa, Ariz.	21 Feb	Coleman	S&ID, Rocket Power

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Table 5. Meetings (Continued)

Subject	Meeting	Location	Date	S&ID Representative	Organizations Represented
Life support aspects	37	Seattle, Wash.	21 Feb	Sherman	S&ID, Boeing
PERT coordination meeting	38	Downey, Calif.	21, 22 Feb	Foist	S&ID, NASA
Schedule wind tunnel tests	39 40	Buffalo, N.Y. Cleveland, Ohio	21-23 Feb	McNary	S&ID, Cornell Aero. Lab. S&ID, Louis Res. Ctr.
Tower jettison	41 42	Rialto, Calif. Costa Mesa, Calif.	22, 23 Feb	Coleman	S&ID, B. F. Goodrich S&ID, Astropower
Facility survey	43	Elkton, Md.	22 Feb	Wermouth	S&ID, Thiokol Chem. Co.
Apollo radiation computer progress	44	Houston, Texas	25 Feb	Voevodsky	S&ID, NASA
Procurement of NASA technical data	45	Houston, Texas	26, 27 Feb	Brayton	S&ID, NASA
Discussion of human impact test program	46	Houston, Texas	26, 27 Feb	Schmidt Brewer	S&ID, NASA
Discussion of aerothermodynamics	47	Mt. View, Calif.	27 Feb	Harthun Kinsler	S&ID, Ames Research Ctr.

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